"LASER TRIANGULATION"

Utilizing the

LASER RANGE POLE SYSTEM

PREPARED BY:

UNITED STATES DEPARTMENT OF THE INTERIOR
BUREAU OF LAND MANAGEMENT
Montana State Office
Billings, Montana

United States Department of Interior
Bureau of Land Management

Report No. 2

November 21, 1978

"LASER TRIANGULATION"
Utilizing the
Laser Range Pole System

Harold W. Grusing
Supervisory Cadastral Surveyor
Montana State Office
Billings, Montana

In a remote area of the Flathead National Forest, about 50 miles north of Kalispell, Montana, a 10-man BLM cadastral survey crew experimented with and tested a unique new method of surveying rugged forested terrain.

The new surveying application utilizes the Laser Range Pole System (LRPS) to facilitate the dependent resurvey and subdivision of sections which form the boundaries of the Public Lands in Township 36 North, Range 22 West, Principal Meridian, Montana (Group 649, MT).

The Laser Range Pole System was originally designed to establish the orientation between two known corner points where mountains, trees or other obstructions bar the way to conventional line of sight instruments. For more information on the operation and development of the Laser Range Pole, see: "The Laser Range Pole In The Forest Service" by Bernard W. Hostrup, printed in the Proceedings of the American Congress on Surveying and Mapping, 34th Annual Meeting, St. Louis, Mo., March 10-15, 1974, Library of Congress Catalog No. 50-33534.

This new LRPS application, "Laser Triangulation," basically involves setting up two LRPS receivers on two control points, one on each end of a known baseline, and turning angles to the mobile LRPS transmitters moving from one corner point to another.

The North Fork of the Flathead Project was selected as an ideal location to test the accuracy, convenience and reliability of using this new LRPS application. This portion of Montana is heavily timbered with mostly

second growth spruce and lodgepole pine with some scattered larch. The forest floor is covered with various varieties of dense underbrush. There is considerable swampland and a few small meadows scattered throughout the area. There are a number of clear-cut logged areas that are mostly grown over with small trees and brush to a height of 7 to 12 feet. The terrain varies from 3600 feet above sea level, along the North Fork of the Flathead River, to over 5000 feet in the surrounding mountains.

During the three months of the project, from June 14, 1978, through September 15, 1978, a wide range of weather conditions prevailed. A lot of rain fell the first month, with heavy fog in the mornings. Low-lying clouds would move into the area, piling up against the high mountain peaks in Glacier National Park. The second month turned dry and hot, with temperatures ranging into the 90's. During this period, high, dry thunderheads would generally build up from the west each afternoon. The last month was cool and wet, with nearly 12 inches of precipitation. The sky was gray and overcast during most of this month. These weather conditions are fairly normal for this part of northwestern Montana.

At the beginning of the project, a triangulation net of temporary control stations was developed (see Diagram #1). From USGS topographic maps, aerial photos and a field investigation, suitable points were selected for control stations, preferably line of sight. Where line of sight stations could not be established, extra care on traverse lines was used to insure accuracy, and the LRPS was used to check alignment. A series of altitude observations on the sun for azimuth were performed at each

control station. The angles and distances between stations were measured with a Hewlett Packard 3810A Distance Meter. Selected found corners in the area to be surveyed were tied to the control stations, using conventional surveying methods. Approximate coordinates could then be assigned to any corner of the original survey.

After the triangulation net was completed, the actual Laser Triangulation Survey was initiated. LRPS receiver units were situated at two of the control stations using the established line between the stations as a triangulation base line. Angles from each of the receivers to a predetermined corner point were calculated. The LRPS transmitter crew, using a compass, the original field notes, topo maps, aerial photos, etc., would then make a brief search in the area of the predetermined corner. If found, the transmitter would be positioned over the corner point, taking care to observe there was not any canopy cover directly overhead. The standard operational procedure for the LRPS was then followed and when both receivers were centered on the laser beam , the coordinates of the corner could be calculated. In the event there was no evidence of the corner readily located, the transmitter would be set up in the search area and the standard operational procedure used to determine the transmitter's position. The transmitter crew was then advised of the move to the precalculated position of the corner. Generally, some evidence of the original monument or accessories would be found after a thorough search in the area of the precalculated position. If no evidence was found, a temporary corner point would be established. The

transmitter crew then moves to the next corner location, and the same procedure is followed. After all the controlling corners on the boundary of a section were located, the necessary subdivision corner positions within the section were calculated and established using the same operational procedure.

A minimum of three "shots" were executed by each receiver to all transmitter positions. Each receiver angle was recorded and the series was then averaged. The angular difference was found to be less than seven seconds on any series of "shots" (see Diagram #2).

Approximately 50 percent of the corner positions were checked by laser triangulation from at least two different base lines. The relative difference of the coordinates of any corner so checked was less than one link in both latitude and departure (see Diagram #3).

Twenty-five percent of the corner positions, established by laser triangulation, were checked by running conventional traverses from known corner positions or control stations. The relative difference between any position established by laser triangulation and checked by traverse was very minor, less than one and one-half links in both latitude and departure (see Diagram #4).

Two LRPS transmitter crews were used, simultaneously, on this project. Each crew consisted of an experienced surveyor and two or three survey aids. Experienced surveyors were needed on the transmitter crews because

corner evidence recovery was very difficult in this area. During the original survey in 1894, most of the corners were monumented with spruce posts, 4x4 inches square, three feet long. Several major fires have swept the area in the past 70 years, destroying much of the original corner evidence. With a lot of persistence and hard work, some evidence was recovered on 90 percent of the original monuments. A total of 150 corner positions were located using the laser triangulation system.

At times the transmitter crews backpacked through swamps and brush up to two miles to reach a corner. The greatest distance either transmitter crew had to move from the first set up in the search area, to the actual corner position, was five chains.

The transmitter battery caused some inconvenience and lost time. In using the LRPS as a searching device, up to 800 transmitter shots were fired per day. The transmitter battery was designed to accommodate about 500 shots daily and was adequate for that number. If a great amount of shots were required, especially boosts because of the extended range involved, the battery would tend to deplete before the end of the day. It is recommended an additional battery be acquired for each transmitter.

One LRPS receiver was equipped with a photo-multiplier (PM) detection unit, as the laser scatter detection component. The second receiver was modified with a silicon avalanche detector (SAD). The PM receiver operated well up to a one mile range and the SAD receiver operated fine up to two miles. Approximately one-half of the triangulations were longer than one mile, making it necessary to move the SAD unit from one control point to the other, a very time consuming situation.

On July 28, the SAD receiver developed a center light spread of 25 seconds to over 3 minutes. During the second week of August, the PM receiver also developed a spread of up to one minute. By meaning the first left light reading and the first right light reading, then lowering the theodolite telescope, the crosshairs would split the transmitter. This was verified by numerous line of sight checks. The problem of center light spreads was time consuming and no plausible explanation causing the spread could be found. There were never any drastic changes in temperature or humidity. The laser scatter became so wide or scattered, the LRPS was completely inoperable the week of September 11-15. The first week of October, the LRPS was checked at Billings, Montana, and the maximum center light spread on both receivers was found to be three seconds. During October the LRPS was used on two additional surveying projects, one in southwestern Montana and the other in west-central Montana. Excellent results were obtained with the LRPS on these two projects with a maximum center light spread of five seconds.

The fragile connectors between the radios and the receivers or transmitters were a continuing problem. During the course of work, one of the fragile pins in the connector broke and the cable had to be replaced. Great care had to be exercised in joining this connector to the radios. It is obvious this connector is a weak link in the system and should be replaced with a connector that can withstand the rigorous treatment it receives.

In 66 working days, from June 14, 1978, to September 15, 1978, 82 miles of completed survey have been finished. This is an average of 1.25 miles completed per day, using the Laser Triangulation System. Using conventional surveying methods, two five-man crews would average from 3/4 to one mile of completed line per day in this area, or a total of 57 miles. Roughly, this calculates into a savings of $310 per mile and a total savings of over $25,000 on this project. It is estimated an additional 25 to 50 percent of completed surveys could have been accomplished, barring the operational and inclement weather problems encountered during this project.

There are several modifications being planned for the LRPS at the present time. It is anticipated these modifications will alleviate most of the operational problems and even better results will be realized on future projects utilizing this LRPS application.

I believe this report points out the LRPS application of "Laser Triangulation" is an accurate, time and labor saving method of surveying in rugged forested terrain.

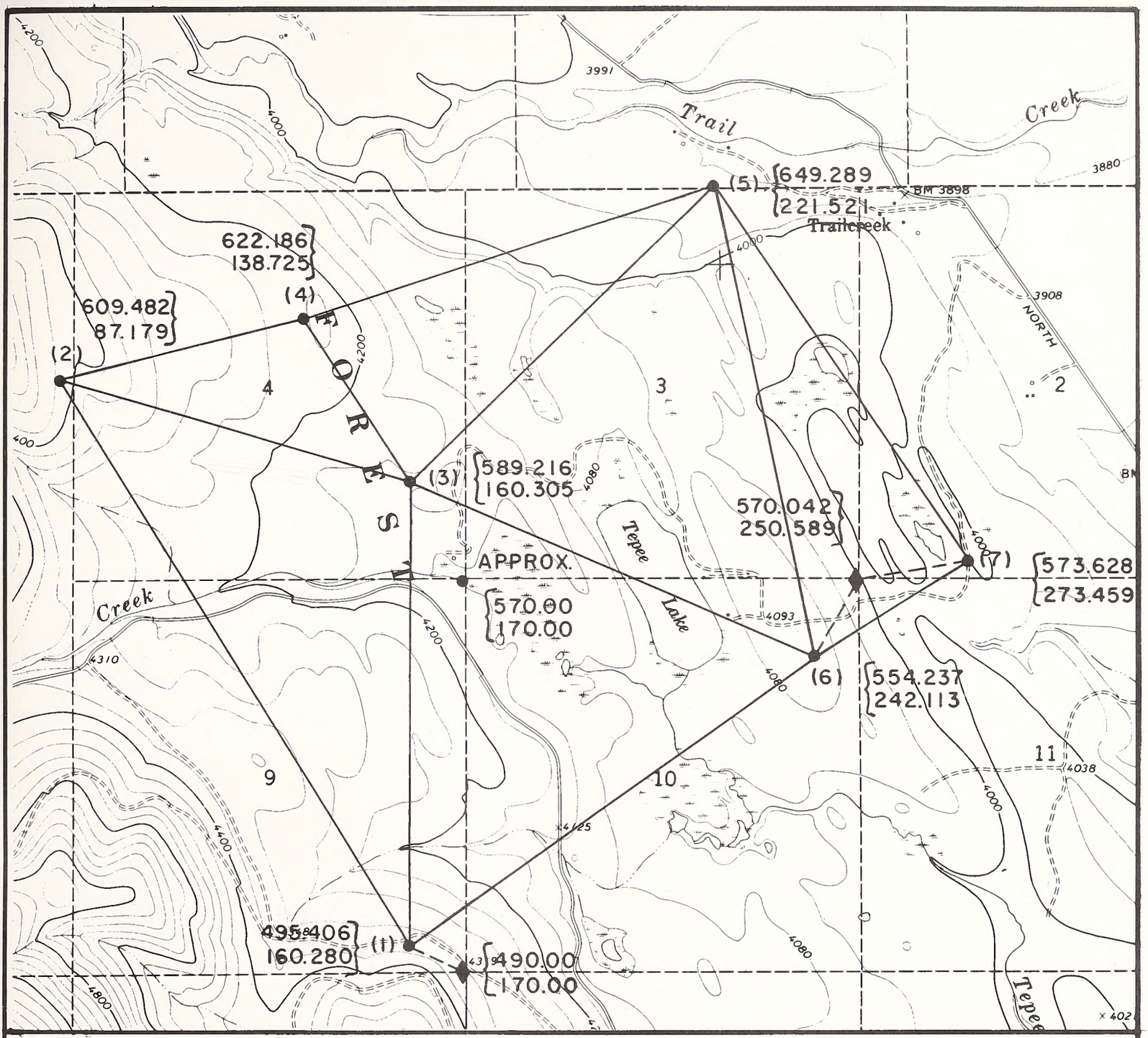

Diagram No. 1

Example of the Establishment of Temporary Control Stations in a Portion of the area Surveyed.

The Plane Coordinate Values of each Station.

The Traverses from Station No. 1 to the Cor. of Secs. 9, 10, 15 & 16 and from Stations No. 6 and No. 7 to the Cor. of Secs. 2, 3, 10 & 11; along with the Coordinates of these Section Corners.

The approximate Coordinates for the Cor. of Secs. 3, 4, 9 & 10

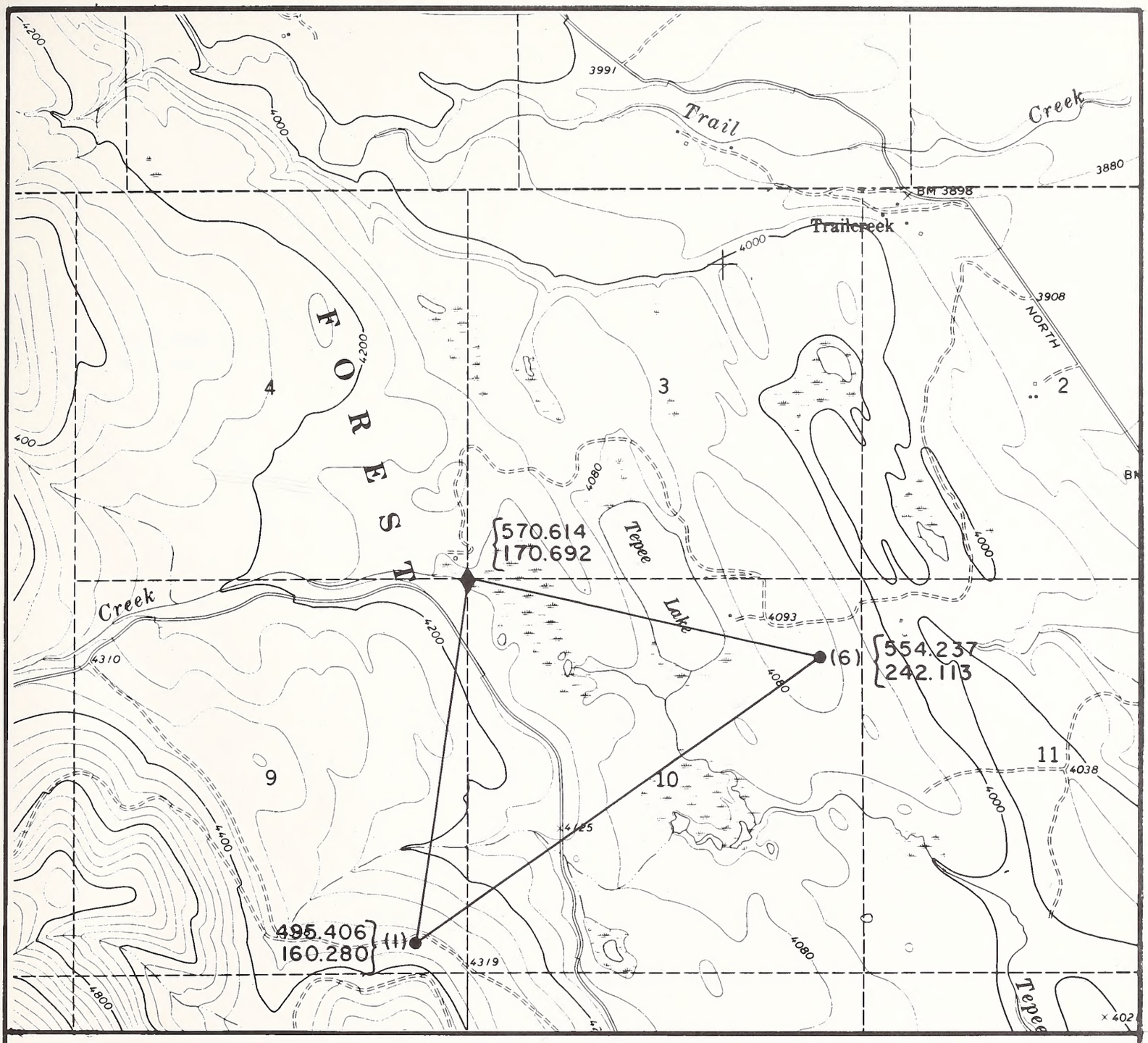

Diagram No. 2

Example of Precision of Angles Turned from Receivers to Transmitter Station.

Series at Station No. 1
(1) 46°24'16"
(2) 46°24'20"
(3) 46°24'18"

Mean
46°24'18"

Series at Station No. 6
(1) 48°37'40"
(2) 48°37'41"
(3) 48°37'40"

Mean
48° 37'40"

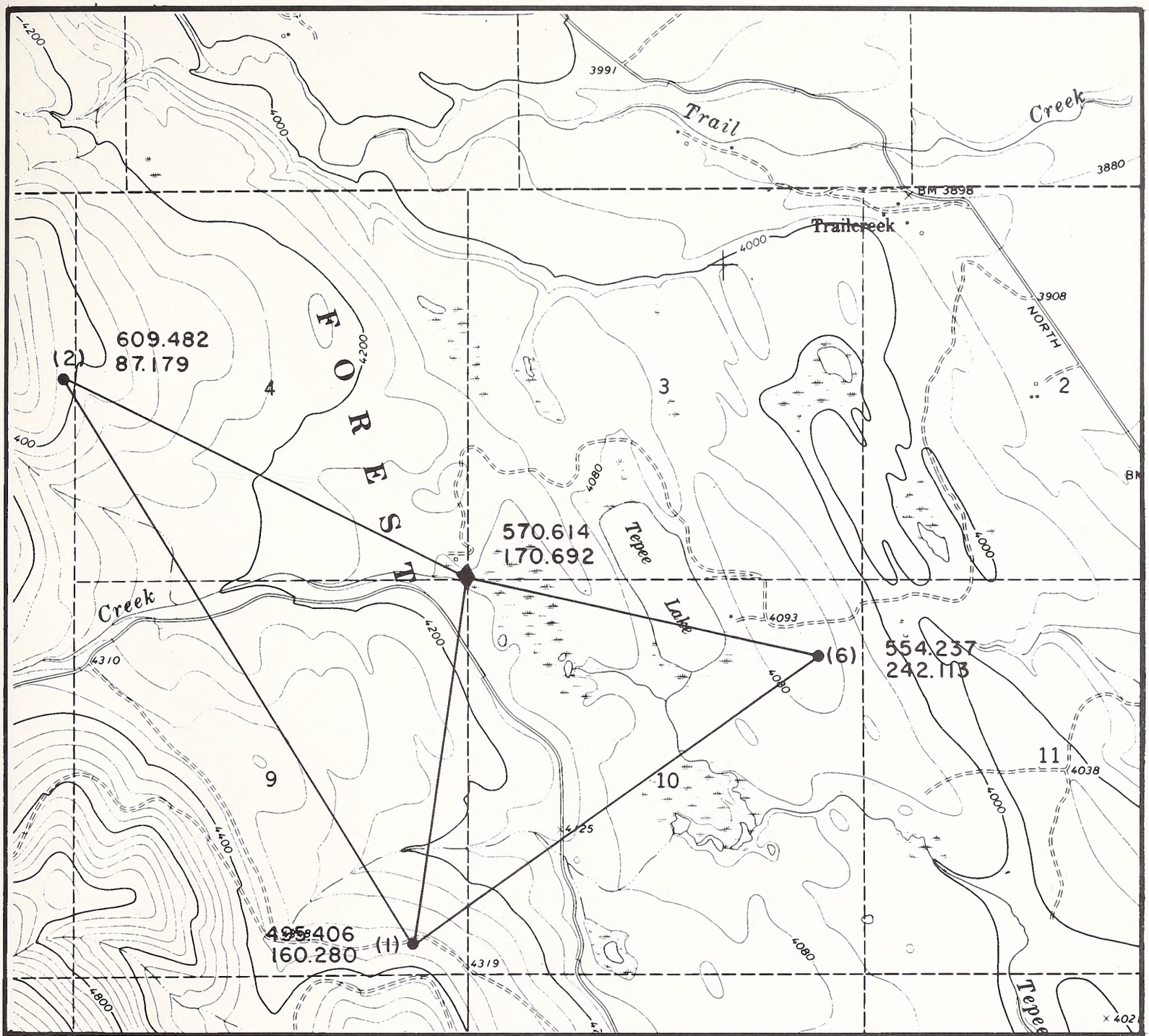

Diagram No. 3

Example of Accuracy Obtained with "Laser Triangulation

Coordinates of Cor. of Secs. 3, 4, 9 & 10, from Base Line 1—6

570.618
170.694

Coordinates of Cor. of Secs. 3, 4, 9 & 10, from Base Line 1—2

570.610
170.690

Mean of Coordinates ——— 570.614
170.692

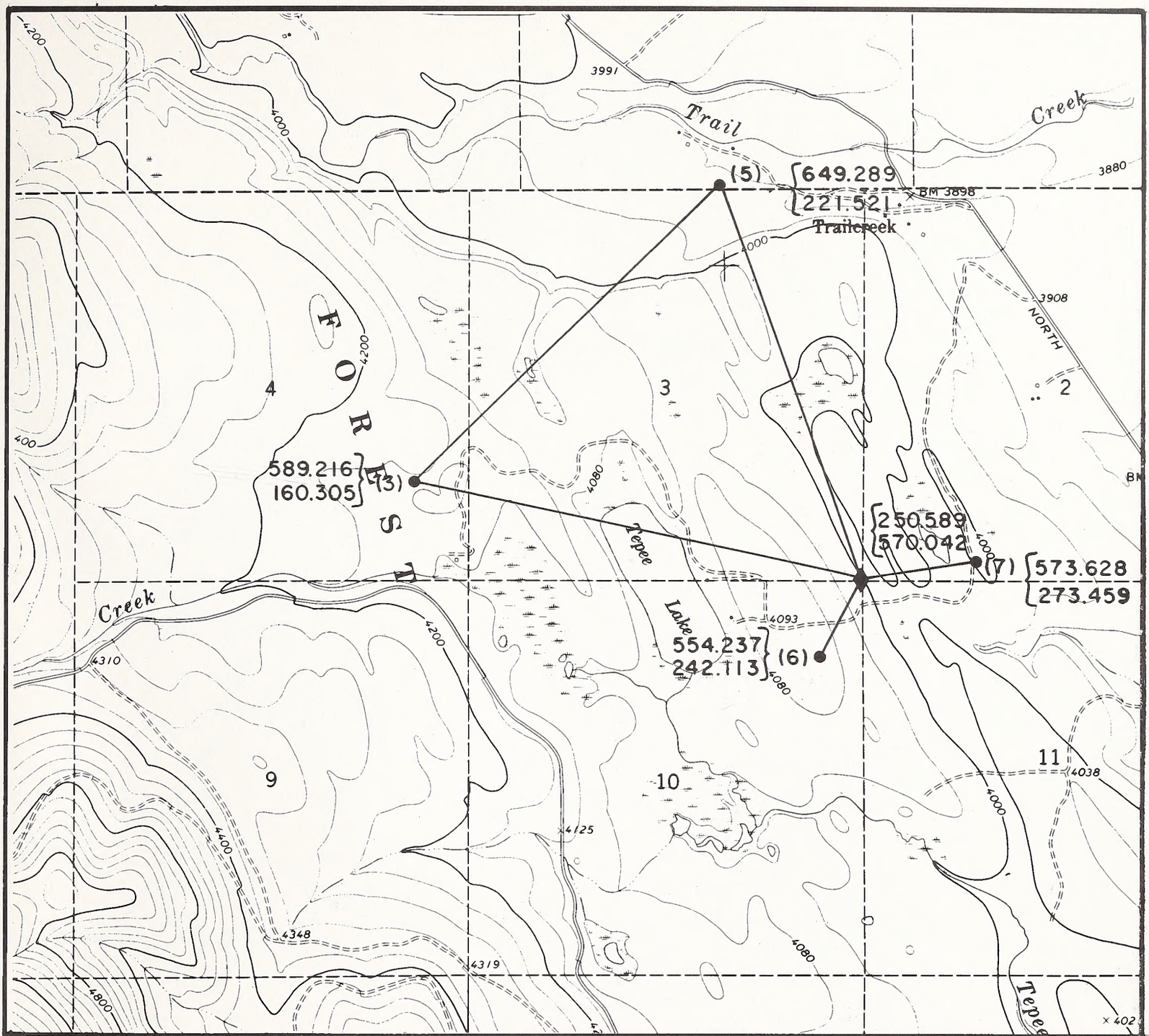

Diagram No. 4

Example of Accuracy Obtained with "Laser Triangulation"

Coordinates of Cor. of Secs. 2, 3, 10 & 11
from.....

Base Line	Traverse No. 6	Traverse No. 7
570.039	570.046	570.042
250.593	250.585	250.590

Mean of Coordinates 570.042
250.589